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## THE EFFECT OF INCORPORATING CASSAVA LEAF MEAL WITH FISH MEAL, GROUNDNUT CAKE AND SOYBEAN MEAL BASED DIETS AT THE EXPENSES OF SOYBEAN MEAL ON GROWTH PERFORMANCE AND FEED UTILIZATION OF CATFISH (*Clarias gariepinus*)

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### ABSTRACT

The potential of cassava leaf meal (CLM) as a partial replacement for soybean meal in the diet of African catfish *Clarias gariepinus* juveniles was carried out in this study. Six isonitrogenous diets containing 35% crude protein were formulated with graded CLM inclusion levels of 0, 5, 10, 15, 20, and 25%. 630 juveniles were randomly distributed into concrete tanks and fed the experimental diets at 3% body weight for 8 weeks in a completely randomized design. Each treatment was replicated thrice for the experiment. Proximate composition and cyanide content of the diets were determined, also, growth performance and nutrient utilization parameters were evaluated. No significant differences ( $p > 0.05$ ) were observed among treatments for growth, feed intake, feed conversion ratio, or protein efficiency ratio. However, fish fed the 10% CLM diet consistently showed higher weight gain, specific growth rate, and protein efficiency ratio compared to other treatments. At higher inclusion levels ( $\geq 20\%$ ), growth performance and feed efficiency tended to decline, likely due to increased dietary fiber and cyanogenic compounds. These findings indicate that cassava leaf meal can replace soybean meal up to 25% without adverse effects on juvenile catfish performance, with an inclusion level of about 10% appearing most favorable. Cassava leaf meal therefore represents a viable, locally available plant protein source for sustainable aquaculture feed formulation.

**Keywords:** Cassava leaf meal, Soybean meal, Growth performance, Catfish, Feed Utilization

### INTRODUCTION

With the fast growth in the aquaculture sector in the recent years, the demand for quality fish feed is continuously increasing. Providing quality fish feed became a

prime aim of every fish farmer. Though fish feed devours around 60% of the production cost, yet it plays the major role in the production and yield outcome (Garlock *et al.*, 2020). One main reason for the high cost of fish feed is due to the increase in demand of fish meal which remains the core of the protein supply of the feed. The quest for possible alternative protein sources to replace partial fish meal in the feed became very important. As fish meal protein sources are expensive and not easily available, plant sources are considered to be one possible alternative that can be used in fish feed without compromising the nutritional quality of the feed (Hardy, 2010; Daniel, 2018). Moreover, use of cheaper and locally available plant sources to substitute the expensive fish meals would mean reduction in the production cost and thereby enhance the profit (Gatlin *et al.*, 2024).

Incorporation of plant sources in fish feed generally has its limitation due to low protein content, presences of anti-nutritional factors such as alkaloids, glycosides, oxalic acids, phytates, cyanoglycosides etc. and their imbalances in some essential amino acids, fatty acids and micronutrients (Thakur & Sharma 2019). The potential of the feedstuffs to be used in fish diets can be established based on their proximate chemical composition (Mzengereza *et al.*, 2014). Efforts are made to remove the anti-nutritional factors in the plant sources (Samtiya & Dhewa 2020). Cassava is root crop cultivated and consumed in Nigeria and the leaf is also known to possess protein at levels of 24%–39.9% dry weight (Awoyinka *et al.* 1995; Miranda, C. G *et al.*, 2024). Cassava leaf meal contains nutrients which can be of value in fish nutrition especially proteins, fat and carbohydrates and also revealed that cassava leaf meal could serve as a protein source in fish feed diets replacing soya bean (Amare *et al.*, 2024). Literature abounds on the use of cassava leaf meal in the diet of *Clarias gariepinus*. However, there is a lacuna on the use of cassava leaf meal as a protein source in the diet of juvenile *Clarias gariepinus*. This study therefore investigated the effects on growth of *Clarias gariepinus* fed diets with cassava *Manihot esculenta* leaf meal as a partial replacement for soybean meal.

## METHODS

### Cassava Leaf Meal Preparation

Cassava leaves were collected from the harvested cassava plant in the feed mill complex of National institute for Freshwater Fisheries Research (NIFFR), New Bussa Niger State, Nigeria. The leaves were dropped in the sun for two hours after which the leaf stalks were detached from the leaflets and finally air dried for two days indoor. After drying, the leaves were milled to powder using a laboratory grinder. A sample of the cassava leaf meal was taken to the analytical laboratory for proximate composition and cyanide content analysis before incorporation into the feeds containing other feed ingredients.

### Experimental Design

Completely randomized design was used to study the effects of graded levels (0, 5, 10, 15, 20 and 25) % of cassava leaf meal inclusion into a basal diet fed to triplicate groups of thirty five juveniles of catfish hybrid for eight weeks (56 days). 35 juveniles per replicate and 3 replicate per treatment with a total of six treatments. In total Six hundred and thirty(630) juveniles of catfish *Clarias gariepinus* were acquired from hatchery complex of NIFFR. They were stocked into the experimental nursery 2m-2m tanks acclimatized for two weeks (Jonsson *et al.*, 1999; Al-Naga, *et al.*,

2022). in Fish Nutrition Experimental site hatchery complex NIFFR during which they were fed the basal diet which serves as the control diet for the experimentation.

### Diets Preparation

Fish meal, groundnut cake, soya beans meal, wheat offal, fish oil, starch, lysine, methionine and cassava leaves meal were the ingredients used for the formulations of the diets (Treatments) for the study. Graded levels 0%, 5%, 10%, 15%, 20% and 25% of cassava leaves meal were incorporated in six diets formulations and recorded as T0, T5, T10, T15, T20 and T25 respectively. Cassava leaves meal was incorporated in each formulation at the expense of soybean meal. Each of the ingredients was milled separately before appropriately weighed strictly following the treatments formulations. The weighed ingredients were mixed thoroughly to obtain a homogenous mixture before addition of water to form dough which were pelleted with a 4 mm die, dried, packaged in polyethylene and kept in an air-tight container before use. Feeding trial was conducted outdoor in concrete tanks in the hatchery complex NIFFR.

Table 1. Composition of 35% crude protein experimental Diet fed to catfish 0 - 8 weeks

Ingredients	T0 0%	T5 5%	T10 10%	T15 15%	T20 20%	T25 25%
CLM 25%	0	5.00	10.00	15.00	20.00	25.00
FFSBM 37%	17.04	15.08	13.25	11.31	9.46	7.57
Fish meal 70%	10.00	10.00	10.00	10.00	10.00	10.00
GNC 45%	39.56	39.48	39.06	38.82	38.56	38.28
Wheat Offal 15%	25.55	22.62	19.87	17.03	14.18	11.35
Starch	2.00	2.00	2.00	2.00	2.00	2.00
Bone Meal	2.00	2.00	2.00	2.00	2.00	2.00
Premix	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.50	0.50	0.50	0.50	0.50	0.50
Lysine	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin C	0.03	0.03	0.03	0.03	0.03	0.03
Vitamin B. Complex	0.02	0.02	0.02	0.02	0.02	0.02
Fish Oil	2.00	2.00	2.00	2.00	2.00	2.00
Total	100	100	100	100	100	100

Note: GNC= groundnut cake, FFSBM= full fat soya beans meal, CLM= cassava leaf meal

CLM 25%= Cassava leaf meal contains 25% crude protein

FFSBM 37%= Full fat soya bean meal contains 37% crude protein

Fish meal 70%= Fish meal contains 70% crude protein

GNC 45%= Groundnut cake contains 45% crude protein

Wheat Offal 15%= Wheat offal contains 15% crude protein

### Stocking, Feeding and Measurements

At the end of acclimatization, fish were not fed a day prior stocking of the concrete tanks with appropriate numbers of juveniles. Thus was to enable the fish emptied their gut for actual initial weight to be obtained and also to reduce stress of the fish at stocking. The total weight, standard and total lengths of the juveniles were taken at the beginning of the experiment, 35 juveniles each were introduced to fish nutrition experimental 2m-2m nursery concrete tanks for all the treatments and three

replicates. Sampling was carried out at the end of every two weeks within the 56 days of the feeding trials. Fish were fed 3% body weight daily (Abdel-Tawwab *et al.*, 2010). The daily rations were divided into two installments, supplied morning (8.00 - 9.00 am) and evening (6.00 – 7.00 pm). Fortnight sampling was adopted for feed adjustments, fish observations, and for health status.

### Biological evaluations

Evaluation of growth performance and nutrient utilization of catfish were determined using (Ojewole *et al.*, 2022) for the following formulae:

- Weight gain (WG) = Final Weight (FW) – Initial Weight (IW).
  - Specific growth rate (SGR) =  $\ln$  final weight (g) -  $\ln$  initial weight (g)/feeding period (day) x 100.
  - Feed conversion ratio (FCR) = Weight of feed fed (g)/weight gain (g).
  - Protein efficiency ratio (PER) = Weight gain/protein consumed
- Survival rate % = final number of fish at the end of experimentation / Initial number of fish stocked x 100.

Data were analyzed for variation using Minitab 19.0 (Stat Soft, Inc., Oklahoma, USA). Treatments means were compared to determine differences using Turkey's test multiple comparisons with level of significance at 5% (Danigman and Yalçındağ, 2023).

## RESULTS

Results of proximate composition and cyanide content of the experimental feeds were presented in table 2 below

Table 2. Proximate and cyanide content analysis of experimental feeds fed to *Clarias gariepinus* juveniles for 0 – 8 weeks.

Treatments	%Moisture Content	% Ash Content	%Crude Fibre	%Crude Protein	%Crude Fat	%Nitrogen Free Extract	Cynide (mg HCN/kg)
T0	7.13±0.24	9.57±0.16	3.61±0.82	37.00±1.30	13.48±1.16	29.19±0.56	0±0.00
T5	6.96±0.36	9.23±0.99	3.94±0.33	36.70±0.70	13.81±0.58	29.19±0.56	0.10±0.00
T10	7.03±0.12	9.49±0.01	3.61±0.82	35.67±0.72	13.85±0.69	30.53±0.01	0.15±0.02
T15	7.16±0.34	9.66±0.50	3.75±0.33	34.47±0.03	13.51±0.45	31.73±0.70	0.22±0.01
T20	7.23±0.58	9.66±0.50	4.05±0.70	35.02±0.48	13.47±0.58	31.86±0.58	0.28±0.01
T25	6.82±0.81	9.65±0.45	4.12±0.94	34.49±0.38	13.84±0.70	32.21±0.60	0.34±0.01

### Proximate composition

The proximate composition of the experimental diets fed to *Clarias gariepinus* juveniles over the 8-week period shows relatively stable nutrient values across all treatments. Moisture content ranged from 6.82–7.23%, indicating that all diets were properly dried and within acceptable storage limits. Ash content (9.23–9.66%) remained fairly constant, suggesting that mineral composition was not markedly affected by increasing cassava leaf meal (CLM) inclusion.

Crude protein values slightly decreased as CLM inclusion increased, from 37.00% in T0 to 34.49% in T25. Although the reduction was gradual, the diets still

maintained protein levels within the acceptable range required for juvenile *Clarias gariepinus*. Crude fibre content increased progressively from 3.61% (T0) to 4.12% (T25), which is expected with higher inclusion of plant-based ingredients such as cassava leaf meal. Similarly, nitrogen free extract (NFE), representing carbohydrate content, increased with higher CLM inclusion, while crude fat values remained relatively stable across treatments (13.47–13.85%).

### Cyanide analysis

Cyanide analysis in fish feed is conducted to determine the concentration of hydrogen cyanide (HCN) released from cyanogenic glycosides present in feed ingredients such as cassava leaf meal (Cheng *et al.*, 2025). The analysis typically involves acid hydrolysis or enzymatic breakdown to liberate bound cyanide, which is then quantified. Common analytical methods include alkaline titration, spectrophotometry, or distillation followed by colorimetric determination. The result is expressed as milligrams of hydrogen cyanide equivalent per kilogram (mg HCN/kg) of dry matter. Accurate cyanide determination is essential because elevated levels can impair growth, reduce feed efficiency, and cause toxicity in fish. Therefore, cyanide analysis helps ensure that processed plant-based feed ingredients are safe for aquaculture use. Cyanide content increased consistently with increasing levels of cassava leaf meal, ranging from 0.00 mg HCN/kg in T0 to 0.34 mg HCN/kg in T25. This trend confirms that cassava leaf meal contributed to the cyanide levels in the diets. However, the recorded values were extremely low and far below toxic levels reported for fish, indicating that the processing method used effectively reduced cyanogenic compounds to safe concentrations.

Tabel 3. Growth performance and nutrient utilization catfish (*Clarias gariepinus*) Juveniles.

Treatments	T0 (0%)	T5 (5%)	T10 (10%)	T15 (15%)	T20 (20%)	T25 (25%)
Total Length	29.66±2.30 <sup>a</sup>	29.77±2.12 <sup>a</sup>	30.50±1.00 <sup>a</sup>	30.06±2.53 <sup>a</sup>	29.42±0.92 <sup>a</sup>	30.66±1.54 <sup>a</sup>
Final Weight	175.3±26.85 <sup>a</sup>	179.3±19.85 <sup>a</sup>	181.9±19.05 <sup>a</sup>	167.5±20.12 <sup>a</sup>	181.4±13.15 <sup>a</sup>	175.1±16.34 <sup>a</sup>
Weight Gain	30.53±8.73 <sup>a</sup>	30.23±4.27 <sup>a</sup>	35.23±9.26 <sup>a</sup>	31.36±9.87 <sup>a</sup>	27.1±6.25 <sup>a</sup>	26.6±12.90 <sup>a</sup>
Feed Intake	171.4±21.66 <sup>a</sup>	183.3±17.18 <sup>a</sup>	175.0±11.48 <sup>a</sup>	175.0±18.55 <sup>a</sup>	188.03±21.51 <sup>a</sup>	176.8±11.44 <sup>a</sup>
FCR	5.79±0.94 <sup>a</sup>	6.09±0.34 <sup>a</sup>	5.13±0.96 <sup>a</sup>	9.39±6.76 <sup>a</sup>	7.14±1.63 <sup>a</sup>	7.60±3.02 <sup>a</sup>
FER	0.17±0.03 <sup>a</sup>	0.16±0.01 <sup>a</sup>	0.19±0.03 <sup>a</sup>	0.17±0.15 <sup>a</sup>	0.14±0.03 <sup>a</sup>	0.15±0.07 <sup>a</sup>
SGR	0.33±0.05 <sup>a</sup>	0.32±0.01 <sup>a</sup>	0.38±0.07 <sup>a</sup>	0.36±0.34 <sup>a</sup>	0.29±0.07 <sup>a</sup>	0.29±0.14 <sup>a</sup>
CF	0.67±0.11 <sup>a</sup>	0.70±0.20 <sup>a</sup>	0.64±0.05 <sup>a</sup>	0.16±0.15 <sup>a</sup>	0.73±0.20 <sup>a</sup>	0.61±0.10 <sup>a</sup>
PI	59.99±7.58 <sup>a</sup>	64.16±6.01 <sup>a</sup>	61.25±4.01 <sup>a</sup>	61.25±6.49 <sup>a</sup>	65.81±7.52 <sup>a</sup>	61.92±4.01 <sup>a</sup>
PER	0.50±0.08 <sup>a</sup>	0.46±0.02 <sup>a</sup>	0.57±0.11 <sup>a</sup>	0.49±0.44 <sup>a</sup>	0.41±0.08 <sup>a</sup>	0.43±0.21 <sup>a</sup>

Values are mean ± standard deviation

<sup>a-b</sup> Mean values in the same row with different superscript differ significantly ( $P < 0.05$ ). T0= 0% cassava leave meal, T5= 5% cassava leave meal, T10= 10% cassava leave meal, T15= 15% cassava leave meal, T20= 20% cassava leave meal, T25= 25% cassava leave meal.

### Growth Performance and Nutrient utilization

The responses of the fish are presented in table 3 below. The group of fish that fed on diet tagged T25 had the highest total length which is similar to group T10 (30.66±) and T20 (29.42±) has the lowest total length and shows no significant difference ( $p > 0.05$ ) with other treatments. The group of fish that were fed T10 (181.90±) had the highest final weight while group T15 (167.57±) has the lowest final weight but shows no significance ( $p > 0.05$ ) with other groups.

The highest weight gain was observed in group T10 (35.23±) follow by group T15 (31.36±) and group T25 has the lowest weight gain but shows no significance difference ( $p>0.05$ ) with other groups. Groups T10 (0.36±) has the highest specific growth rate while group T20 has the lowest specific growth rate but shows no significance difference ( $p>0.05$ ) with other groups.

Feed intake was observed to be high in group T20 (188.03±) follow by group T5, T20 respectively while group T10 (171.40±) has the lowest feed intake but also does not show no significance difference ( $p>0.05$ ) with other groups. Feed efficiency was observed to be high in group fed T10 (0.19±) follow by T0 (0.70±) while lowest feed efficiency was recorded in T20 (0.14±) but show no significance difference ( $p>0.05$ ) with the other treatments.

Condition factor and protein intake were observed to be high in group T20 (0.73±), (65.81±) and T5 (0.70±), (64.16±) respectively but condition factor is very low in T25 (0.61±) while protein intake is very low in T10 (59.99±) and both shows no significance difference ( $p>0.05$ ) with the other groups. Protein efficiency ratio was observed to be high in group T10 (0.57±) follow by T0 (0.50±) while group T20 (0.41±) has the lowest protein efficiency ratio but also show no significant differences ( $p>0.05$ ).

## DISCUSSION

The current study investigated the effects of graded cassava leaf meal (CLM) inclusion (0–25%) on the growth performance and feed utilization of catfish. The results showed no significant differences ( $p>0.05$ ) among treatments for total length, final weight, weight gain, feed intake, FCR, SGR, condition factor, protein intake, or PER. This indicates that replacing soybean meal with CLM up to 25% did not compromise the result of growth performance of the fish during the experimental period. The absence of significant variation suggests that *Clarias gariepinus* juveniles were able to physiologically tolerate the inclusion levels tested without severe impairment in nutrient utilization.

Despite the absence of significance ( $p>0.05$ ), the values showed that the 10% CLM treatment yielded the highest weight gain (35.23 g), SGR (0.38), and PER (0.57). Such observations have been reported in studies where moderate inclusion of cassava leaf meal improved growth performance due to an optimal balance of digestible nutrients and manageable levels of anti-nutritional factors (Bureau *et al.*, 1995). However, in this finding, the absence of significance ( $p>0.05$ ) could also be attributed to the levels of anti-nutritional factors present. Additionally, both cassava leaf meal and soybean meal (full fat) are plant sources and may be limiting in methionine and lysine, which are essential amino acids, potentially reducing overall diet quality.

Higher inclusion levels ( $\geq 20\%$ ) showed slightly poorer responses in growth and feed efficiency. These effects are associated with increased anti-nutritional factors such as cyanogenic glycosides and tannins, compounded by high fiber content that impairs or slows down digestibility. This observation is in line with findings by (Sutriana, 2020; Ravindran & Ravindran 1993; and Alamu *et al.* 2021).

Cyanide, a significant anti-nutrient in cassava foliage, has been shown to depress growth and feed efficiency in African catfish when inclusion levels increase beyond 10–20% replacement of soybean meal (Sutriana, 2020). This effect may also be linked to the processing method used for the cassava leaf meal in this study, which involved sun drying for two hours followed by further drying under shade, potentially

insufficient to significantly reduce anti-nutritional factors. As shown in the proximate composition results, cyanide content increased progressively with increasing CLM inclusion, which may have contributed to reduced nutrient utilization efficiency at higher inclusion levels.

Similar findings were reported for Nile tilapia, where increased cassava leaf meal inclusion led to declines in performance (N. G., & K. L. 1989; Olude, O. *et al.*, 2023). This finding aligns with the biology of *Clarias* species, which are carnivorous-omnivorous fish with relatively shorter intestines, making it more difficult for them to efficiently digest high-fiber plant materials. Such species are generally less efficient at digesting high-fiber plant materials compared to herbivorous fish species, making them more sensitive to elevated fiber levels in practical diets.

The relatively high FCR values (5.13–9.39) compared to the optimal catfish feed conversion ratio (<2.0) indicate overall low feed efficiency. To a large extent, this may be attributed to ingredient digestibility, the 3% biomass feeding rate used in the experiment, quality and size of fish seeds, and experimental conditions such as water availability and quality. Environmental factors, including temperature and sunlight fluctuations observed during the experiment, may also have influenced performance. However, the lack of significant variation across treatments suggests that CLM inclusion up to 25% did not detrimentally impact feed efficiency compared to conventional diets. Essential amino acid deficiencies can limit protein synthesis and growth even when crude protein levels appear adequate. Although the crude protein levels of the diets remained within acceptable ranges for *Clarias gariepinus* juveniles, protein quality rather than quantity may have influenced performance outcomes. This limitation may partly explain why significant improvements in growth were not observed despite relatively adequate crude protein levels.

Overall, while high CLM inclusion levels may impair growth and feed utilization, moderate inclusion (around 10%) appears acceptable and possibly advantageous. Nevertheless, proper management of anti-nutritional factors remains essential to maximize the nutritional value of cassava leaf meal in catfish diets because higher inclusion levels may gradually reduce performance due to increased fiber content, anti-nutritional factors, and potential essential amino acid imbalances. Therefore, while CLM shows potential as a cost-effective alternative protein source, proper processing methods to reduce cyanogenic compounds and strategies such as amino acid supplementation may be necessary to maximize its nutritional value in aquafeeds.

## CONCLUSION

Cassava leaf meal can be incorporated into catfish diets up to 25% without significant negative impact on growth or feed utilization. Moreover, a 10% inclusion level shows better performance in weight gain, SGR, and PER, indicating an optimal balance of nutrient supply and digestibility. Cassava leaf meal demonstrates promise as a sustainable, locally available protein alternative in aquaculture feed formulations.

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